APPENDIX 11 D
PROCESS TRAILER CARBON FILTRATION UNIT AND UNPACK AREA CARBON FILTER UNIT CARBON BREAKTHROUGH CALCULATION SHEETS

A5D

CALCULATION SHEET

Calculation # _____ Page 1 of 2

Revision # _____ Attachments YES / NO

Calculation Sheet MMD-1 UNPACK AREA CARBON FILTER DESIGN

Prepared by C. CUDWORTH Date 12/13/96 | Checked by _____ Date _____

References Documents: | Project # _____

PURPOSE: TO DETERMINE THE BREAK THROUGH TIME OF THE 1ST 2" THICK CARBON BED OF THE UNPACK AREA CARBON FILTER UNIT

EQUATIONS:

$$t_b = \frac{\rho_b W_e}{V_L C_o}\left[\lambda - \lambda_c\right]$$ WHERE:

$$\lambda_c = \frac{V_L}{K_V} \ln \frac{C_o}{C_b}$$

$$K_V = 1.82\, a\, V_L \left[\frac{D_A G}{\mu}\right]^{-0.51}\left[\frac{\mu}{P D_V}\right]^{-2/3}$$

t_b = TIME TO BREAKTHROUGH, S
C_o = CHALLENGE CONCENTRATION OF AGENT, g/cm³
W_e = CARBON CAPACITY, g/g
ρ_b = BULK (APPARENT) DENSITY OF CARBON, g/cm
λ = DEPTH OF CARBON BED, CM
λ_c = CRITICAL BED DEPTH, CM
V_L = LINEAR VELOCITY OF AIR THROUGH BED, CM/
C_b = BREAKTHROUGH CONCENTRATION OF AGENT, g/c
K_V = FIRST ORDER RATE CONSTANT FOR ADSORPTION, S
a = PARTICLE SURFACE AREA/BED VOLUME $6(1-\varepsilon)/D_p$, CM^{-1}
D_p = PARTICLE DIAMETER, CM
ε = BED VOID FRACTION
G = MASS FLOW RATE OF AIR (ρV_L), $g/cm^2 \cdot S$
μ = VISCOSITY OF AIR, g/CM-S
P = DENSITY OF AIR, g/cm^3
D_V = DIFFUSIVITY OF AGENT IN AIR, CM^2/S (ABOUT 0.07 CM^2/S FOR GB AT AMBIEN

INPUT DATA:

1. CHALLENGE CONCENTRATION IS BASED ON JACADS DESIGN BASIS MAXIMUM FILTER CHALLENGE OF 40 mg/m^3 CONTAINED IN MITRE REPORT #93W0000034, ASSESSMENT OF CARBON FILTER PERFORMANCE, 9/93
2. GB AS THE MOST VOLATILE AND LEAST FAVORABLY ADSORBED AGENT IS A SUITABLE SURROGATE FOR THE OTHER AGENTS MUSTARD AND VX, WHICH ARE CAPTURED BY THE MECHANISM OF MECHANICAL ADSORPTION.

$C_o = 40\ mg/m^3 = 4 \times 10^{-8}\ g/cm^3$ CHALLENGE CONCENTRATION OF GB
$\rho_b = 0.63\ g/cm^3$ MINIMUM BULK APPARENT DENSITY - SPEC
$D_p = 0.10$ cm AVERAGE PARTICLE SIZE 12 x 30 MESH
$W_e = 0.21\ g/g$ CARBON CAPACITY FOR GB
$V_L = 14.23\ cm/s$
$\lambda = 2'' = 5.08$ cm
$C_b = 0.0001\ mg/m^3 = 1 \times 10^{-13}\ g/cm^3$ FROM MMD SPEC FOR GB
$D_V = 0.07\ cm^2/s$
$\mu = 187.499 \times 10^{-6}\ g/cm\text{-}S$ VISCOSITY OF AIR @ 68°F
$P = 1.1833 \times 10^{-3}\ g/cm^3$ DENSITY OF AIR

CALCULATION SHEET

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Calculation Sheet MMD-1 UNPACK AREA CARBON FILTER DESIGN

Prepared by _____ Date _____ | Checked by _____ Date _____

References Documents: | Project # _____

$\varepsilon = 0.4$

$a = 6(1-\varepsilon)/D_p = 6(1-0.4)/0.10 = 36\ cm^{-1}$

$G = PV_L = (1.1833 \times 10^{-3})(15.4) = 18.223 \times 10^{-3}\ g/cm^2 s$

$K_V = (1.82)(36)(14.23)(9.719)^{-0.51}(2.264)^{-2/3}$

$K_V = (1.82)(36)(14.23)(.3136)(.5799)$

$K_V = 169.55\ s^{-1}$

$\lambda_c = \frac{14.23}{169.55} \ln \frac{4 \times 10^{-8}}{1 \times 10^{-13}}$

$= 1.08\ cm$

$t_b = (0.63)(0.21)(5.08 - 1.08)/(14.23)(4 \times 10^{-8})$

$t_b = 929,700\ sec = 258\ HR$

CALCULATION SHEET

Calculation # _____ Page 1 of 2

Revision # _____ Attachments YES / NO

Calculation Sheet MMD-1 PROCESS TRAILER CARBON FILTER DESIGN

Prepared by C. CUDWORTH Date 12/13/96 | Checked by _____ Date _____

References Documents: | Project # _____

PURPOSE: TO DETERMINE THE BREAK THROUGH TIME OF THE 1ST 2" THICK CARBON BED OF THE PROCESS TRAILER CARBON FILTER UNIT.

EQUATIONS:

$$t_b = \frac{\rho_b W_e}{V_L C_o}\left[\lambda - \lambda_c\right]$$

$$\lambda_c = \frac{V_L}{K_V} \ln \frac{C_o}{C_b}$$

$$K_V = 1.82\, a\, V_L \left[\frac{D_p G}{\mu}\right]^{-0.51} \left[\frac{\mu}{\rho D_V}\right]^{-2/3}$$

WHERE:

t_b = TIME TO BREAKTHROUGH, S
C_o = CHALLENGE CONCENTRATION OF AGENT, g/cm
W_e = CARBON CAPACITY, g/g
ρ_b = BULK (APPARENT) DENSITY OF CARBON, g/cm³
λ = DEPTH OF CARBON BED, cm
λ_c = CRITICAL BED DEPTH, cm
V_L = LINEAR VELOCITY OF AIR THROUGH BED, cm/s
C_b = BREAKTHROUGH CONCENTRATION OF AGENT, g/cm
K_V = FIRST ORDER RATE CONSTANT FOR ADSORPTION, s⁻¹
a = PARTICLE SURFACE AREA/BED VOLUME $6(1-\varepsilon)/D_p$, cm⁻¹
D_p = PARTICLE DIAMETER, cm
ε = BED VOID FRACTION
G = MASS FLOW RATE OF AIR (ρV_L), g/cm²-s
μ = VISCOSITY OF AIR, g/cm-s
ρ = DENSITY OF AIR, g/cm³
D_V = DIFFUSIVITY OF AGENT IN AIR, cm²/s (ABOUT 0.07 cm²/s FOR GB AT AMBIENT)

INPUT DATA:

1. CHALLENGE CONCENTRATION IS BASED ON JACADS DESIGN BASIS MAXIMUM FILTER CHALLENGE OF 40 mg/m³ CONTAINED IN MITRE REPORT #93W0000034, ASSESSMENT OF CARBON FILTER PERFORMANCE, 9/93
2. GB AS THE MOST VOLATILE AND LEAST FAVORABLY ADSORBED AGENT IS A SUITABLE SURROGATE FOR THE OTHER AGENTS MUSTARD AND VX, WHICH ARE CAPTURED BY THE MECHANISM OF MECHANICAL ADSORPTION.

C_o = 40 mg/m³ = 4×10^{-8} g/cm³ CHALLENGE CONCENTRATION OF GB
ρ_b = 0.63 g/cm³ MINIMUM BULK APPARENT DENSITY - SPEC
D_p = 0.10 cm AVERAGE PARTICLE SIZE 12 X 30 MESH
W_e = 0.21 g/g CARBON CAPACITY FOR GB
V_L = 15.4 cm/s
λ = 2" = 5.08 cm
C_b = 0.0001 mg/m³ = 1×10^{-13} g/cm³ FROM MMD SPEC FOR GB
D_V = 0.07 cm²/s
μ = 187.499×10^{-6} g/cm-s VISCOSITY OF AIR @ 68°F
ρ = 1.1833×10^{-3} g/cm³ DENSITY OF AIR

CALCULATION SHEET

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Revision # _____ Attachments YES / NO

Calculation Sheet MMD-1 PROCESS TRAILER CARBON FILTER DESIGN

Prepared by _____ Date _____	Checked by _____ Date _____
References Documents:	Project # _____

$\varepsilon = 0.4$

$a = 6(1-\varepsilon)/D_p = 6(1-0.4)/0.10 = 36\ cm^{-1}$

$G = \rho V_L = (1.1833 \times 10^{-3})(15.4) = 18.223 \times 10^{-3}\ g/cm^2 \cdot s$

$K_V = (1.82)(36)(15.4)(9.719)^{-0.5}(2.264)^{-2/3}$

$K_V = (1.82)(36)(15.4)(.3136)(.5799)$

$K_V = 183.52\ s^{-1}$

$\lambda_c = \frac{15.4}{183.52}$ en $\frac{4 \times 10^{-8}}{1 \times 10^{-13}}$

$\lambda_c = 1.08\ cm$

$t_b = (0.63)(0.21)(5.08 - 1.08)/(15.4)(4 \times 10^{-8})$

$t_b = 859{,}100\ SEC = 238\ HR$